Assessment of Ecological Conditions and Potential of Pastures, Meadows and Steppes Landscapes of Georgia

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Abstract: The natural diversity of Georgia is outstanding in the world. This is particularly true with the subtropical and moderate belts of the country presenting over seventy natural landscapes, from humid subtropical or light semiarid forests through moist and Alpine landscapes. Such a variety is the result of several factors, with the following ones being most important: geographical location (location along the border of the tropical and moderate belts), effect of the Black Sea (which never freezes), altitudinal zoning (up to 5200 ml) and several-thousand-year-long history of the economic use of the territory.

The highly diverse landscapes of Georgia complicate the study of the geographical-ecological (geo-ecological) properties of the country. Among such properties, horizontal and vertical structure of landscapes, energy and substance transformation in the landscape (functioning), forms and scales of influence on the landscapes, landscape stability and function, and landscape condition and potential have a particular importance.

The condition of landscapes is determined by the forms and scales of external influence. The character of influence can be considered by the ability of self-regeneration of the landscape structure. It is admitted that if the impact applies to the biologic components only, the landscape preserves the self-generation ability. The self-regeneration mechanism is impossible to maintain if: 1. the influence coincides with or stimulates (increases) the negative natural processes; 2. The basic landscape creator component or relief and climate is under the impact; 3. One ecosystem is changed by another equivalent one.

Potential of landscapes is a spatial-and-time category ensuing from the natural properties of the landscapes, results of anthropogenic impact and kinds and trends of the territory use. In some cases, they attribute the landscape potential to the terms of landscape comfort and quantitative indicators of the landscape structure and components, what gives a too general view of the landscape potential.

Condition and potential of landscapes are important issues of territorial planning, eventually determining the forms of use, protection and sustainable development of pastures, meadows and steep landscapes.

The article evaluates the ecological condition and potential of those landscapes (ecosystems - pastures, meadows and steppes) of Georgia, which are greatly influenced by both human economic activity and climate change trends.

Keywords: Georgia, Landscape, Structure, Geography, Sustainable development.

INTRODUCTION

Georgia is distinguished for the highest landscape diversity in Europe. The altitude of the relief in Georgia changes within the limits of 0 – 5201 meters. Mountains, 33% - by hills and knolls, and the rest of it - by lowland and plain, present 54% of its territory. There are all forms of reliefs known in the world present in Georgia. The geographical location of Georgia, its dissected relief and variety of the climate in the country stipulate the high values of the landscape diversity. There are 13 types and 72 genera of landscapes in Georgia (Figure **1**), which, if considered in proportion with the territory of the country, is the highest indicator in Europe.

The highly diverse landscapes (Erikstad, act.2015, Deng, act.2020, Groot, 2003) of Georgia complicate the study of the geographical-ecological (geo-ecological) properties of the country. Among such properties, horizontal and vertical structure of landscapes, energy and substance transformation in the landscape (functioning), forms and scales of influence on the landscapes, landscape stability and function (Anthony, 2007, Aragon, 2011), and landscape condition and potential have a particular importance (Elizbarashvili, Meladze, atc.2022).

The natural diversity of Georgia is outstanding in the world. This is particularly true with the subtropical and moderate belts of the country presenting over seventy natural landscapes, from humid subtropical or light semiarid forests through moist and Alpine landscapes. Such a variety is the result of several factors, with the following ones being most important: geographical location (location along the border of the tropical and moderate belts), the Black Sea, which never freezes,

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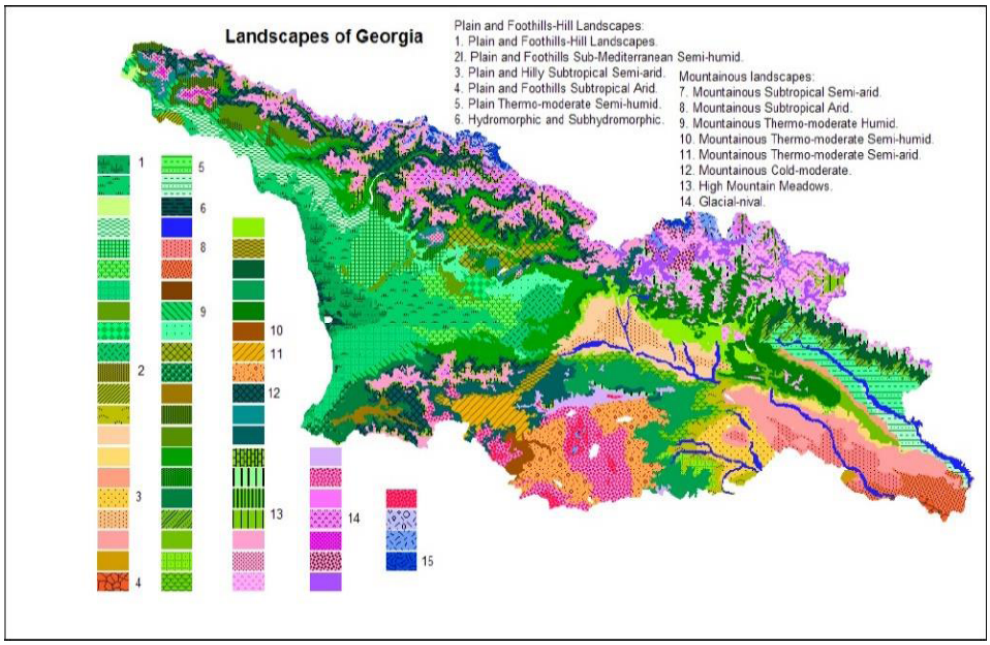


Figure 1: Landscapes of Georgia (Beruchashvili, 1979).

altitudinal zoning (up to 5200 ml) and several-thousand-year-long history of the economic use of the territory (Biological, 2000, Geography, 2000).

With its landscape variety (related to the area), Georgia is an outstanding country both, in Europe and in the world. Georgia, as a part of the Caucasus, is: (a) among the world's top 25 biologically richest and endangered "hot spots", (b) among the world's top 200 most sensitive and vulnerable eco-regions with particularly rich biodiversity, (c) a habitat of endemic birds, (d) among the world's agro-biodiversity centers, (e) one of the "hot spots" with large herbivorous animals (Geography, 2000, Nature of, 2013).

Such landscape diversity leads to many forms of its use. As a result of human economic activity, the landscape of Georgian plains and hills, semi-arid and semi-humid ecosystems, steppes and meadouw have been almost completely transformed. The impact on summer and winter pastures is high. The largest part of winter pastures is formed in semi-arid climate conditions, which gradually loses productivity and undergoes degradation as a result of climate change

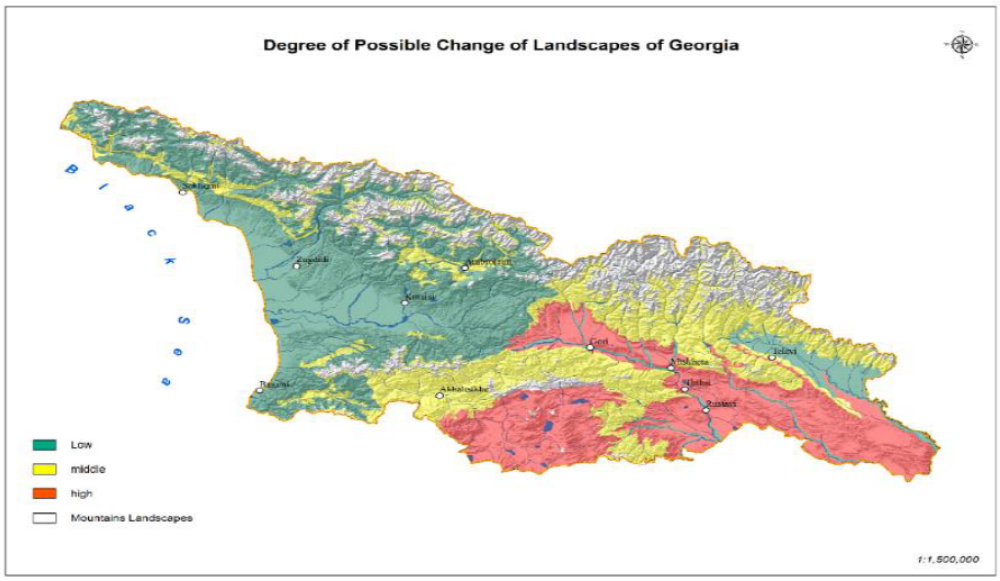


Figure 2: Degree of possible change of Landscapes of Georgia.

(Elizbarashvili, Meladze, atc.2022). Assessment of their ecological condition and potential, in the light of climate change, is an urgent scientific task.

Climate change trends show that these ecosystems and landscapes are characterized by the most unstable environmental conditions. The problems associated with both - climate change and human economic impact - can already be seen here. If such processes continue with the same intensity, substantial degradation awaits the given landscapes. Stopping such processes requires a complex assessment of their condition and potential, which is the main scientific task of our article.

MATERIALS AND METHODS

On the basis of the landscape analysis and landscape (Beruchashvili, 1995, https://education.nationalgeographic) synthesis, concrete results are obtained: the theoretical concept of spatial and time approach in landscape researches is developed and confirmed, certification of landscapes of Georgia is done, geographic information systems and databases are developed, landscape and ecological characteristics of Georgia are studied, and methodological fundamentals of landscape planning are developed.

The methods by Beruchashvili used for Georgia included the analysis of literature, maps and statistics, field data, remote sensing and GIS analysis. Landscape maps of the Caucasus scaled 1:1,000,000 (Beruchashvili, 1979, 1983) were used as the landscape basis. The current status of landscapes, natural and anthropogenic conflicts, natural potential and sustainability of areas were evaluated by geo-ecological analysis and synthesis, Methodology of landscape planning (Piloting, 2009; Landscape, 2009).

The goal of the geo-ecological investigation of the landscape is to identify these various mutual connections and the spatial-temporal variety, which exists between the nature and the society. By that, the research of territorial organization, landscape components and ecological condition of its morphological units, and their interrelation are the principal essence of the geo-ecological investigations.

A geo-ecological investigation of a landscape is implemented in some stages, with the following stages as the most important ones: landscape-ecological analysis (inventory) of the territory (general geographical, landscape, social-economical, ecological) and estimation. During the general geographical analysis, the geographical location of the study territory, area, borders of the neighboring regions, common physical-geographic and social-economic features are considered. During the landscape analysis, the scale needed for the investigation purposes, natural potential of the territory, interrelation between the physical-geographic components, basic features of structure and functioning, dynamics and ethology are identified (Elizbarashvili, Meladze, atc.2022). It must be noted that the characteristics of natural potential of the territory important for the geo-ecological investigation are: properties of the relief and geological formation, climate and climatic resources, waters and water resources, plants and herbal resources, biodiversity, animal world and zoo resources, soils and soil resources (Landscape stability map, 2015, Deng, act.2020, Tim Theisser, Joachim Aurbacher, David Bedoshvili, atc. 2019).

The analysis of the ecological condition of the territory can be done through the determination of the ecological condition of the natural environment where the situational analysis is intended to accomplish, together with the ecological condition of geographical components and their application. The ultimate goal of the analysis of general geographical, landscape, social-economic and ecologic situation (Figure **2**) of the territory is the geo-ecological synthesis, which on its part, consists of several stages (Ecology-geographical map, 2007, Environmental functions map, 2015). At the first stage of the geo-ecological synthesis, the character of the current condition of landscapes (by structural, dynamical, functional and ethological characteristics, as well as forms and scales of the influence) and potential are identified.

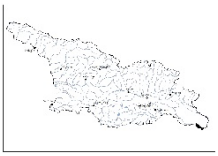
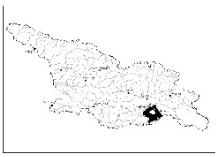
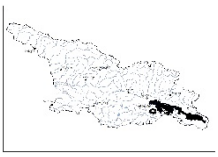
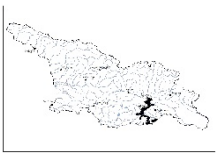
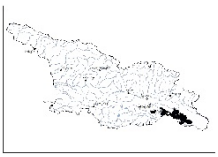
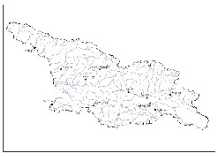
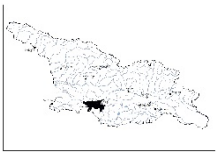
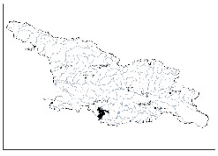
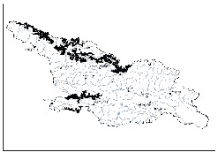
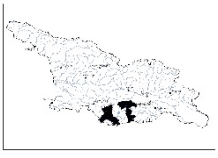
RESULTS

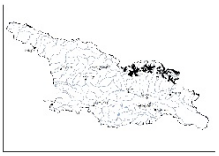
1. Assessment of the Landscape Condition

Forms and scales of external influence determine the condition of landscapes. The character of influence can be considered by ability of self-regeneration of the landscape structure. It is admitted that if the influence concerns the biologic components only, the landscape maintains the self-regeneration ability. The self-regeneration mechanism is impossible to maintain, if:

1. The influence coincides or stimulates (increases) the negative natural processes (machines, salinity, ravines, erosion and so on);

Table 1: Geographical and Ecological Characteristics of Landscapes

Landscapes	Geographical Area (Schematic map)	Geographical Characteristics	Ecological Characteristics
Plain and foothill arid (pastures)		Altitude 350 - 450 m, T^0= -1.0, +24.8 Precipitation: 350 - 450 mm Evaporation - 800 mm Phyto mass: 2 - 5 t/ha	Drought - 4 months Process: accumulation, erosion Impact - Animal husbandry Climate change – medium Sustainability – medium
Plain and Hilly Subtropical Semiarid (steppes)		Altitude 250 - 350 m, T^0=+0.3, +25.3 Precipitation: 375 – 450 mm Evaporation - 550 mm Phyto mass: 1.5-5 t/ha	Drought - 3 months Process: accumulation Impact - Animal husbandry, mowing Climate change – medium Sustainability - low
Plain and Foothills Subtropical Arid (pastures)		Altitude 500 - 1000 m, T^0= -1.5, +23.7 Precipitation: 600 - 700 mm Evaporation - 700 mm Phyto mass: 5 - 25 t/ha	Drought - 2 months Process: accumulation, erosion Impact - Animal husbandry, mowing Climate change – medium Sustainability - medium
Plain thermo-moderate semi-humid (pastures)		Altitude 400 – 1000 m, T^0=+0.3, +23.6 Precipitation: 400 – 550 mm Evaporation - 450 mm Phyto mass: 5-25 t/ha	Drought - 2 months Process: erosion, denudation Impact - Animal husbandry Climate change – low Sustainability – low
Low Mountainous Subtropical Semiarid (pastures)		Altitude 500 - 1000 m, T^0= -1.1, +22.5 Precipitation: 350 - 450 mm Evaporation - 700 mm Phyto mass: 1 - 3 t/ha	Drought - 3 months Process: accumulation, erosion Impact - Animal husbandry, mowing Climate change – medium Sustainability - low
Low Mountainous Subtropical Arid (pastures)		Altitude 200 - 400 m, T^0= -1.0, +24.0 Precipitation: 300 - 400 mm Evaporation - 800 mm Phyto mass: 1 - 4 t/ha	Drought - 3 months Process: denudation Impact - Animal husbandry Climate change – medium Sustainability - low
Middle Mountainous Thermo-Moderate Semi-humid (meadows)		Altitude 800 - 1300 m, T^0= -3.0, +25.0 Precipitation: 400 - 500 mm Evaporation - 800 mm Phyto mass: 3 - 5 t/ha	Drought - 3 months Process: accumulation, erosion Impact - Animal husbandry, mowing Climate change – low Sustainability - medium
Middle Mountainous Thermo-Moderate Semiarid (meadows)		Altitude 1700 - 2000 m, T^0= -1.0, +24.0 Precipitation: 400 - 500 mm Evaporation - 900 mm Phyto mass: 1 - 3 t/ha	Drought - 2 months Process: erosion, denudation Impact - Animal husbandry, mowing Climate change – low Sustainability – medium
High Mountainous Cold-Moderate (meadows)		Altitude 2000 - 2600 m, T^0= -5.0, +13.4 Precipitation: 1500 - 2000 mm Evaporation - 700 mm Phнto mass: 20 - 30 t/ha	Drought - 0 months Process: erosion, denudation Impact - Animal husbandry, mowing Climate change – low Sustainability - high
High Mountainous Thermo-Moderate Semiarid (meadows, steppe)		Altitude 1700 - 2300 m, T^0= -7.0, +24.0 Precipitation: 600 – 700 mm Evaporation - 900 mm Phнto mass: 10 - 40 t/ha	Drought - 2 months Process: accumulation Impact - Animal husbandry, mowing Climate change – low Sustainability - high

High mountain alpine (meadows)		Altitude 2800 - 3400 m, T^0= -5.0, +13.4 Precipitation: 1500 - 2000 mm Evaporation - 600 mm Phнto mass: 30 - 40 t/ha	Drought - 0 months Process: erosion, denudation Impact - Animal husbandry, mowing Climate change – low Sustainability - high

2. The basic landscape creator component or relief and climate is under influence.

3. One ecosystem is changed by another equivalent one.

During the analysis of anthropogenic influence, it must be supposed that a landscape needs self-regeneration ability to recover its initial ability. This is particularly true with the landscapes having the resource reproduction and environment recovery functions. Anthropogenic influence, with its forms, varies by agriculture, techno genic (industry, building, transport and others), techno-ecological (exploitation of the forests, conflagration and others), recreation activities and others. Anthropogenic influence can be synchronous (various at the same times – in case of many-sided application of the territory) or iterate (when another changes one kind of influence). Synchronous influence is usually common for an urban like area, *i.e*. in the landscapes where agricultural, forest, and water exploitation take place at the same time. The influence is iterated in the regions where seasonal agricultural and recreational load is great. Such landscapes are seen in the mountains. Plane landscapes among the mountains of Georgia must be considered as an area of a synchronous influence with diversified agricultural and social activities of the population, high concentration of the most (80%) of the society and established living environment, industrial, agricultural and transport infrastructure and so on. The influence of agricultural activities is intense but is periodical. Despite the periodic nature of the agro-technical influence, it is so essential that the agrarian landscape structure completely depend on the purpose of such an influence (Elizbarashvili, Meladze, atc.2022). With agro-landscapes, the goal of the agro-influence is the maintenance of the desirable stable development and functioning of agriculture. The less the agriculture corresponds to the landscape-ecologic conditions, the less it is stable to the environment factors, the more the agro technical influence is and the less profitable the production is.

Photo 1: Low mountainous arid landscapes. East Georgia

Photo 2: High Mountain alpine and glacier landscapes. North Georgia

Photo 3: High Mountain steppe, meadows and volcanic landscapes. South Georgia

The third kind of influence, the mixed influence, is the determinant of environmental state and is typical to

the landscapes, where the anthropogenic influence has an episodic character (Elizbarashvili, atc. 2011, Michael, 2014). In this case, the structure and functioning of the landscape are stipulated both, by natural and by anthropogenic factors. Thus, the majority of landscapes of Georgia belong to the category of strongly modified landscapes. The second rank moderately to completely, moderately and practically transformed landscapes.

The assessment of the ecological condition of pastures, steppes and meadows landscapes (Photo **1**,**2**,**3**) shows that it is mainly related to landforms and human activities. The situation is particularly difficult in the landscapes of flat terrain and low mountains, where the rate of transformation exceeds 2/3. Where the condition of the landscape is mainly determined by natural processes, their modern condition is as close to natural as possible. Such are the high mountain alpine landscapes where, despite intensive grazing, natural indicators of structure and function are still preserved.

2. Assessment of the Landscape Potential

Study of the landscape potential is one of the principal issues in sustainable development, landscape ecology, and its due identification is an important precondition for the identification of the social-economic functions, protection and rational use of the landscapes. The potential of landscapes (Ecological, 2007), if not considering individual theoretical opinions and numerous publications dedicated to the issue of bio-productivity of the eco-systems, is virtually an unexplored scientific direction.

Potential of landscapes is a spatial-and-time category ensuing from the natural properties of the landscapes, results of anthropogenic impact and kinds and trends of the territory use. In some cases (Elizbarashvili, 2018), they attribute the landscape potential to the terms of landscape comfort and quantitative indicators of the landscape structure and components, what gives too general view of a landscape potential. The scientific-geographical literary sources more or less thoroughly give the examples of determination and classification of the landscape potential. However, the scarce theoretical and practical studies in this direction do not allow for their thorough systematization (Elizbarashvili, Meladze, atc.2022).

The potential of landscapes may change or transform in response to the societal demands, with resource and ecological demands being of primary importance and residential and recreational demands

Table 2: Pasture, Steep and Meadows Landscape Types of Georgia and its Value of Condition for Sustainable Development

Pastures, steppes and meadows landscape of Georgia	% of transformation of natural structure	Determined processes of Landscape	Value of condition for sustainable development
1. Plain and foothills arid (pastures) 29	70	Artificial and natural	middle
2. Plain and Hilly Subtropical Semiarid (steppes)	73	Artificial and natural	low
3. Plain and Foothills Subtropical Arid (pastures)	65	Artificial and natural	middle
4. Plain thermo-moderate semi-humid (pastures)	55	Artificial and Natural	middle
5. Low Mountainous Subtropical Semiarid (pastures)	85	Artificial	low
6. Low Mountainous Subtropical Arid (pastures)	60	Artificial and natural	middle
7. Middle Mountainous Thermo-Moderate Semi-humid (meadows)	70	Artificial and natural	middle
8. Middle Mountainous Thermo-Moderate Semiarid (meadows)	85	Artificial	low
9. High Mountainous Cold-moderate (meadows)	30	Natural	high
10. High Mountainous Thermo-Moderate Semiarid (meadows, steppe)	20	Natural	High
11. High mountain alpine (meadows)	10	Natural	high

being of a secondary importance presently. Aiming at maintaining the landscape potential to the required degree, the society in its activities has to consider the maintenance of such properties of the landscape, as the landscape structure and functioning, stability, biodiversity, etc. (Elizbarashvili, 2016, Ecology-geographical map, 2007, Environmental potential map, 2015, Deng, act.2020. Elizbarashvili, Meladze, atc.2022, https://www.eea.europa.eu/publications/).

Potential of landscape can be considered by its private characteristics, in particular:

1. Agricultural potential – ability of a landscape to produce;

2. Biologic potential - renovation and restoring of the biomass;

3. Water potential – ability of a landscape to transform the moisture obtained from atmosphere, which will be used both, by the living organisms and by the society.

4. Mineral potential – the potential associated with the landscape distribution of mineral resources.

5. Energy potential – the energy contained in the landscape, reproduced or transformed by landscape for economic purpose is meant:

6. Recreation potential.

7. Urban and economic potential (Elizbarashvili, 2016, 2018, 2019, Tratalos, 2007).

In Georgia, depending on fuel and energy resources, they distinguish between the subtropical semiarid (in East Georgia) and subtropical humid (in West Georgia) plains located among the mountains and hills. The maximum exponents of biomass are found in the middle-mountain landscapes with beech, dark coniferous and hardwood (oak-forest) plants. Depending on solar resources, they distinguish between the subtropical, low mountain, semiarid East Georgian plain landscapes. In South Georgia, the solar energy can be obtained from even semiarid, high mountain meadow landscape, and in West Georgia the mountain subalpine and alpine meadow landscape facilitates the generation of solar energy (here the number of cloudless days reach 25-29%). Rich in wind resources are the landscapes of ravines of

Table 3: Pasture, Steep and Meadows Landscape Types of Georgia, their Potential and Value for Sustainable Development

Pastures, steppes and meadows landscape of Georgia	Resource potential	Recreation potential	Urban and economic potential	Value of potential for sustainable development
1. Plain and foothills arid (pastures)	Agricultural	middle	middle	high
2. Plain and Hilly Subtropical Semiarid (steep)	Agricultural, energy	middle	middle	high
3. Plain and Foothills Subtropical Arid (pastures)	energy	low	low	middle
4. Plain thermo-moderate semi humid (pastures)	Agricultural	middle	middle	high
5. Low Mountainous Subtropical Semiarid (pastures)	Biological, energy	middle	middle	high
6. Low Mountainous Subtropical Arid (pastures)	Energy	low	low	middle
7. Middle Mountainous Thermo-Moderate Semi-humid (meadows)	Biological	high	low	high
8. Middle Mountainous Thermo-Moderate Semiarid (meadows)	Biological, water	middle	low	high
9. High Mountainous Cold-moderate (meadows)	Biological water	middle	low	high
10. High Mountainous Thermo-Moderate Semiarid (meadows, steppe)	Biological Energy	middle	High	High
11. High mountain alpine (meadows)	Biological Energy, water	high	low	high

mountainous plain rivers along the borders of East and West Georgia (middle-mountain temperate warm beech forest), as well as temperate semiarid landscapes of the volcanic plateau of South Georgia (Geography, 2000, Willemen, 2007).

The analysis of the presented table allows for a number of conclusions:

1. The resource potential of the landscapes represented on the plains is related to agriculture. At the same time, they mostly have medium or low level recreational and urban potential (Keshtkaran, 2019, Mitz, atc.2021). These landscapes are generally characterized by a high potential for sustainable development.

2. The resource potential of low mountain landscapes is related to biological productivity and energy sources, while the recreational and urban potential is low or medium. This situation is due to their climatic characteristics (small amount of precipitation, large number of sunny days, high air temperatures);

3. The potential of medium mountain landscapes is related to biological productivity and formation of water resources. Their recreational potential is of medium or high level, and their urban potential is of low scale. This kind of situation is due to a favorable climate (which leads to the formation of forests and meadows), the accumulation of snowmelt waters and a healthy ecological environment;

4. The potential of high mountain landscapes is related to biological productivity, climate and formation of water resources. Their recreational potential is high, which is due to the large number of mountain resorts, healthy air and long snow cover. It is understood that the urban potential of high mountain landscapes is low due to the difficult terrain and low potential for infrastructure development.

DISCUSSION

The assessment of conditions of the landscapes provides an important link between the landscape planning and the sustainable development, where the main role is played by natural as well as socio-economic factors (Elizbarashvili, atc.2022). Human activities determine the condition of 20% of landscapes of Georgia. At the present stage, an important task is to determine the current state of the changed landscapes, with the landscapes with agro modifications being important of them.

The conditions of the transformed landscapes in many respects depend on the natural potential, which is gradually considered in case of review of specialization separately for the directions of agricultural industry, economy and urbanization of Georgia. Therefore, at this stage, the major scientific task is to develop the methodology to determine not only the conditions, but also the potential of the transformed landscapes.

Maintaining the ecological stability and potential of summer and winter pastures, as well as steppes, is an essential task of the state. They are the most vulnerable to climate change. Consideration of such trends is necessary for the further development of stable agriculture, energy and recreational farming.

CONCLUSION

In Georgia, in the scientific and practical plan, the processes connected with the introduction of methodology and experience of sustainable ecology development and landscape planning (Piloting, 2009, https://www.fzp.czu.cz/en/r-9408) are actively realized. Similar processes are connected with two aspects: Association Agreement of Georgia with the European Union and ratification of the European Landscape Convention. On the basis of the principles of sustainable development and landscape planning (European landscape, 2000), in recent years, new protected areas have been established (two national parks in South Georgia, at the cross-border with Armenia and Turkey and two national parks in North Georgia, at the prospective cross-border with Russia) and the planning of cultural landscapes in historical-ethnographic regions in Georgia.

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